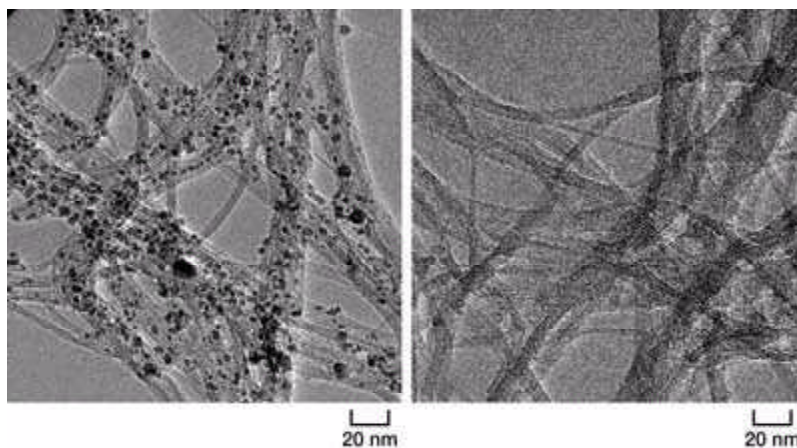


New Method Developed To Purify Single Wall Carbon Nanotubes for Aerospace Applications

Single wall carbon nanotubes have attracted considerable attention because of their remarkable mechanical properties and electrical and thermal conductivities. Use of these materials as primary or secondary reinforcements in polymers or ceramics could lead to new materials with significantly enhanced mechanical strength and electrical and thermal conductivity. Use of carbon-nanotube-reinforced materials in aerospace components will enable substantial reductions in component weight and improvements in durability and safety. Potential applications for single wall carbon nanotubes include lightweight components for vehicle structures and propulsion systems, fuel cell components (bipolar plates and electrodes) and battery electrodes, and ultra-lightweight materials for use in solar sails.

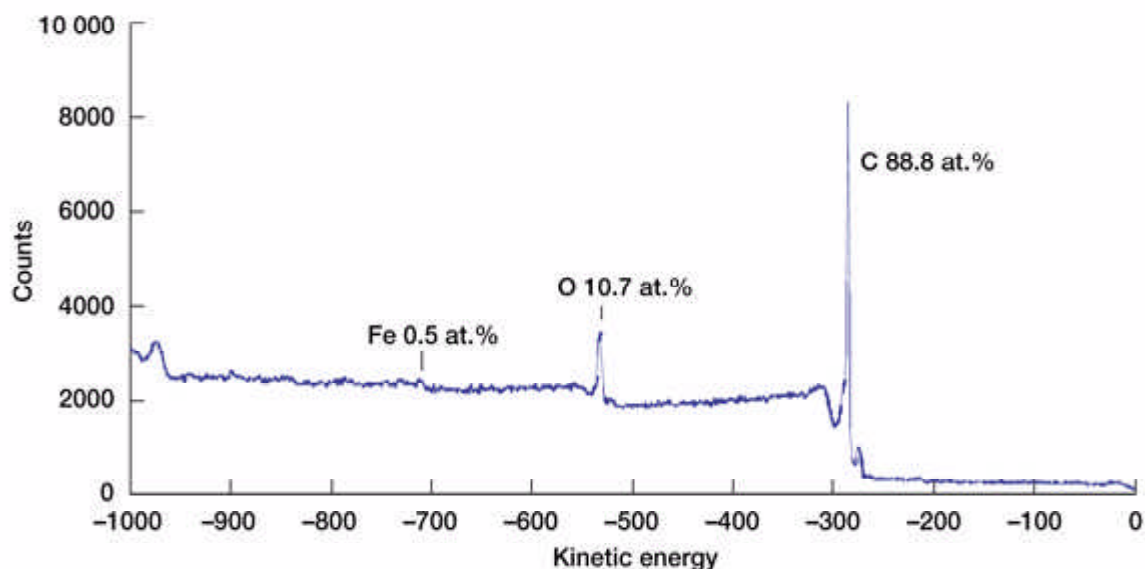
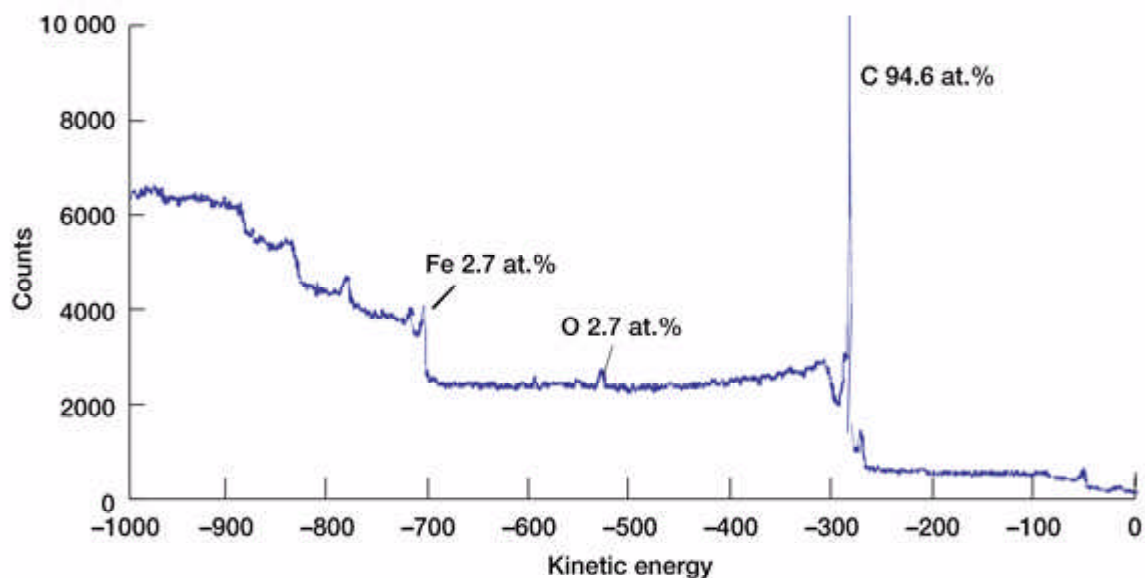
A major barrier to the successful use of carbon nanotubes in these components is the need for methods to economically produce pure carbon nanotubes in large enough quantities to not only evaluate their suitability for certain applications but also produce actual components. Most carbon nanotube synthesis methods, including the HiPCO (high-pressure carbon monoxide) method developed by Smalley and others (ref. 1), employ metal catalysts that remain trapped in the final product. These catalyst impurities can affect nanotube properties and accelerate their decomposition. The development of techniques to remove most, if not all, of these impurities is essential to their successful use in practical applications.



Transmission electron micrographs of carbon nanotubes. Left: Crude. Right: Purified. Note the absence of iron catalyst particles (black spots) in the purified tubes.

A new method has been developed at the NASA Glenn Research Center to purify gram-scale quantities of single wall carbon nanotubes. This method, a modification of a gas-phase purification technique previously reported by Smalley and others (ref. 2), uses a

combination of high-temperature oxidations and repeated extractions with nitric and hydrochloric acid. This improved procedure significantly reduces the amount of impurities (catalyst and nonnanotube forms of carbon) within the nanotubes, increasing their stability significantly. The onset of decomposition of the purified nanotubes (determined by thermal gravimetric analysis in air) is more than 300 °C higher than that of the crude nanotubes. Transmission electron microscopy analysis of nanotubes purified by this method reveals near complete removal of iron catalyst particles (see the preceding photomicrographs). Analysis of the nanotubes using inductively coupled plasma spectroscopy revealed that the iron content of the nanotubes was reduced from 22.7 wt% in the crude nanotubes to less than 0.02 wt%. X-ray photoelectron spectroscopy (see the following graphs) revealed a decrease in iron content after purification as well as an increase in oxygen content due to the formation of carboxylic acid groups on the surface of the nanotubes. Nanotubes purified by this improved method can be readily dispersed in common organic solvents, in particular N,N-dimethylformamide, using prolonged ultrasonic treatment. These dispersions can then be used to incorporate single wall carbon nanotubes into polymer films.



X-ray photoelectron spectra of carbon nanotubes. Top: Crude. Bottom: Purified. Note the decrease in iron content in the purified tubes and the increased oxygen content due to the formation of carboxylic acid groups on the nanotube surface.

This work is a collaboration between Glenn and the NASA Center for High Performance Polymers and Composites at Clark Atlanta University.

Find out more about research by Glenn's Polymers Branch

<http://www.grc.nasa.gov/WWW/MDWeb/5150/Polymers.html>

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Glenn contact: Dr. Michael A. Meador, 216-433-9518, Michael.A.Meador@nasa.gov

Clark Atlanta University contact: Marisabel Lebron, 216-433-2292,
Marisabel.Lebron@nasa.gov

Authors: Marisabel Lebron and Dr. Michael A. Meador

Headquarters program office: OAT

Programs/Projects: Propulsion and Power, RAC